

**Wyoming Carbon Sequestration
Advisory Committee**

**REPORT
to the
57th WYOMING LEGISLATURE**

December 1, 2001

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Pursuant to Enrolled Act No. 107 of the 56th Wyoming Legislature, the Wyoming Carbon Sequestration Advisory Committee is required to submit this report of committee findings and recommendations to the Legislature. This report represents much work and coordination of private landowners, the University of Wyoming, industry and state and federal agencies.

I. Executive Summary

Atmospheric levels of carbon dioxide have increased by over 30% since the start of the industrial revolution and are projected to nearly double by the end of the century. The terrestrial ecosystem represents a tremendous sink for this carbon dioxide through its uptake by plants and sequestration in the soil as soil organic matter and as other stable carbon sources (such as wood).

Agriculture can play a significant role in the reduction of atmospheric carbon dioxide through land use change and changes in management practices used on croplands, forest lands and rangelands. **Agroforestry** represents a very large potential sink for carbon and can be achieved through planting of shelterbelts, living snow fences and general agroforestry production. In the paper we present numerous examples of carbon sequestration potential for various cropland, forest and rangeland management strategies.

Measuring, verification and modeling of carbon sequestration potential at the state-wide level can be accomplished but will require additional knowledge on the subject of soil organic matter as influenced by soil series and management scenarios. Knowledge of carbon storage potential for a specific management practice under similar climatic conditions and soil types may be adequate for assessing carbon storage and its possible marketing. In other words, carbon sequestration and marketing may best be tied to conservation/management practices because

specific verification will be very difficult, time consuming and costly because of the magnitude of spatial and temporal variability inherent in soil organic carbon levels.

II. Carbon Sequestration Advisory Committee Members

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III. Introduction

There is concern about the level of greenhouse gases (methane, carbon dioxide (CO₂), and nitrous oxide) in the atmosphere and how they might affect our terrestrial ecosystems by their presence and the projected impact on atmospheric temperatures. The world climate has varied dramatically over geologic time. Four major glacial cycles have occurred during the past 400,000 years. Over this period, atmospheric levels of CO₂ have only varied by 20% from the average concentration of 240 ppm. Concentration of CO₂ and methane in the atmosphere are now 30% and 250% higher than the maximum ever recorded for these gases. The concentration of CO₂ at the beginning of the industrial revolution was about 280 ppm and has increased to over 365 ppm and is expected to exceed 600 ppm by the end of the century. This rise in greenhouse gas concentrations has raised concerns among scientists and policy makers as to their potential impact on temperature and other climatic factors and what impacts these changes might have on world agriculture. Climate change scenarios have predicted that shifts in precipitation patterns will significantly alter ecosystems, increase drought and create greater weather extremes.

Only half of the CO₂ that has been released into the atmosphere by human activities over the past centuries is currently present in the atmosphere. More than half of the CO₂ released through burning of fossil fuels during the last 10-20 years has been absorbed by the land and oceans. This process is referred to as sequestration and the land and oceans are considered carbon “sinks.” The magnitude and residual nature of these carbon sinks is not well understood. Significant advances in understanding carbon sequestration have been made in the last 10-15 years. Land use changes and management scenarios/practices can significantly influence carbon

sequestration. Carbon dioxide concentrations will greatly influence plant community diversity and plants can be managed as an effective means of removing CO₂ from the atmosphere through an important growth process, “photosynthesis.” Photosynthesis is the process whereby plants use CO₂ and sunlight to produce sugars for plant cell metabolism and growth. The terrestrial ecosystems (forestlands, croplands, rangelands, and other lands) comprise a huge land resource area that has a great potential for carbon sequestration. A greater level of knowledge exists as to the role of forests in carbon sequestration. Evidence is also available that indicates croplands and rangelands can play an important role as carbon sinks. The processes and role of management of these lands in carbon sequestration is not fully understood or the potential magnitude thoroughly assessed.

Improving management and implementing land use changes could result in a very large carbon storage capacity by terrestrial ecosystems. Storing carbon in soils as organic matter will greatly enhance soil productivity and water storage. Important secondary benefits to water quality, biodiversity, and other attributes of the environment may also occur. Soil organic matter is the basic source of nutrients for plant growth and the energy source for soil microbiological activity and biological nutrient cycling. Past agricultural practices have greatly reduced (by as much as 60%) the level of soil organic matter in agricultural soils; therefore, making the potential for sequestration even greater in these lands.

In Wyoming, we have approximately 1,046,000 acres of dryland agricultural, 1,426,000 acres of irrigated agricultural lands, 23,265,000 acres of privately owned rangelands, and 1,698,000 acres of private forest lands. Wyoming also has 17,437,000 acres of BLM managed lands, 2,393,000 acres of national parks, 9,168,000 acres of U.S. Forest Service managed lands, and 3,724,000 acres of state land. Optimum management of these lands for productivity and

carbon sequestration can produce significant off-sets of CO₂ emission from energy production, transportation, agriculture, and other sources. These off-sets could be marketed through emission trading to ensure sound economic growth of the State. Examples of emissions trading already exist for such compounds as sulfur and nitrous oxide; therefore, marketing of CO₂-C emissions would be feasible and could produce economic benefits to agriculture. Carbon marketing will be discussed in greater detail later in this report. To ensure a common understanding of terminology on this subject, we have attached a glossary of terms, Appendix A.

IV. Effects of Agricultural And Agroforestry Management Practices on Carbon Sequestration

The terrestrial biosphere of the world represents a significant carbon sink. It contains about 1.6×10^{21} tons of carbon in the surface 39 inches of soil (Eswaran et al. 1995; Batjes 1996) and another 6.6×10^{20} tons of carbon residue in the vegetation (Houghton 1995; Schimel 1995) which, together is three times the amount of carbon in the atmosphere. Therefore, it should be obvious that any change in the carbon storage by plants or soil should have significant implications for atmospheric carbon dioxide.

Grazing lands occupy about 7.5 billion acres of land worldwide, about twice the area of cultivated agriculture (Buyanovsky and Wanger 1998; Bronson et al. 1997). Therefore, any shifts in management that results in increased plant biomass, enhanced ecosystem health, or improved residue management will result in improved soil organic carbon storage. Within the last decade, research has been initiated to address the effects of cropland and grazing land management alternatives on soil carbon storage. This research has resulted in the development of carbon storage factors for various tillage practices, crop rotations and grazing management strategies. Examples of this research are: Schuman et al. (1999) showed that well managed grazing of

mixed-grass rangelands resulted in an increase of 0.13 tons of carbon/acre/yr storage compared to non-grazed exclosures; Eve et al. (2001) estimate that going from crop-fallow to continuous cropping or going from conventional tillage to no-till would result in an increase in soil of 0.09 tons of carbon/acre/yr; U.S. Forest Service, Lincoln, Nebraska estimates that living snow fence plantings in North Dakota, South Dakota, Nebraska, Iowa and Minnesota would store 192,000 tons of carbon over a 20 year period. They also estimate that farmstead shelterbelts and field windbreaks in the northcentral U.S. could store 14 million tons and 237 million tons of carbon, respectively, over 20 years. Much additional research is needed to refine and develop carbon storage factors for commonly used conservation practices and management strategies in Wyoming; however, considerable knowledge (qualitative and quantitative) and data do exist that can be used as guides to develop carbon storage potentials and estimate quantity under various agricultural systems. Appendix B lists some carbon storage potentials for various cropland, rangeland, forestland and agroforestry practices that are applicable to Wyoming agriculture. Appendix C also gives an example of benefits that might be expected by implementing a specific BMP.

Rehabilitation of degraded lands represents a significant carbon storage potential. Marginal, highly erodible croplands and mined lands represent a significant potential for carbon storage because the soil resource has either been degraded by long-term tillage practices that have resulted in 30-60% reduction of the soil organic matter concentration due to oxidation and decomposition or through the soil salvage process (in mining) that results in the mixing of the surface organic matter rich soil horizon with lower soil horizons that are lower in soil organic matter. The soil salvage, storage, and mixing phenomena that occurs during mining and reclamation results in a soil media that closely represents that of soils that have been cropped for

decades. Since the soil organic matter in these soils may have been greatly reduced, these soils have a greater potential for carbon storage before they reach an equilibrium that is determined by the soil; geology, climate, and topography. This equilibrium can be exceeded but would likely require inputs such as fertilizer or water (irrigation) that would have to be carefully assessed to determine if the carbon storage potential to be gained was greater than any CO₂ emission resulting from the production of the input(s).

Agricultural and forestry best management practices (BMPs) listed in Appendix B have significant potential for storing carbon in the soil or plants in Wyoming. These BMPs are not new to the agriculture and forestry industry in Wyoming, as these industries have been using these BMPs for years or decades. Additional BMPs, new plant species, and other technological innovations will likely emerge when the benefits for sequestering carbon are realized.

The most significant factors that will determine the extent and rate at which BMPs can be adopted by the agriculture and forestry industry in Wyoming include:

- 1) increases in profits or losses associated with a change in the kind or amount of agricultural and forestry products produced as a result of adopting BMPs,
 - a) value of an associated increase in the sustainability of the land to produce products as a result of adopting BMPs,
 - b) capital needed to adopt BMPs, and whether these costs are short term or long term
 - c) amount of gross proceeds from the sale of carbon credits,
 - d) availability of monetary benefits for complimentary federal, state or local programs that directly or indirectly promote the use of BMPs.

Land use and land ownership in Wyoming influence where individual BMPs will potentially be used in Wyoming. Land use should not be a controlling factor for carbon sequestration because there are many BMPs for cropland, rangeland, and forestland.

The effectiveness of a BMP to sequester carbon is influenced by several factors. Soil and climate influence the amount of plant growth and, consequently, influence the potential for carbon sequestration. The manner of implementing a BMP, the efficiency of the BMP at sequestering carbon, the use of multiple BMPs, and the length of time that a BMP is used are also factors that will impact carbon sequestration potential.

There are many valuable benefits that result from using BMPs. A strong positive relationship exists among BMPs, soil quality, and carbon sequestration. Agricultural productivity and sustainability is strongly linked to soil quality. As the amount of organic carbon increases in the soil, there is an increase in the ability of the soil to take up water, hold water and nutrients, and produce healthier and more diverse populations of microorganisms in the soil. The result is

that the land has a greater potential for plant growth and an increased resistance to degradation and an increased resilience to variable precipitation. Improving the productivity of the land and restoring degraded lands result in a potential to produce a greater variety and higher yields of agricultural and forestry products. The value of the land inevitably increases and its potential to produce products increases. Considering the value of credits for sequestered carbon in today's market, the value of these benefits exceeds the market value of the sequestered carbon. Another benefit of using some cropland BMPs is the decrease in the total carbon emissions produced by equipment using fossil fuels. This occurs as the result of a reduction in the number of tillage operations performed.

Methods for Measuring, Modeling and Verifying Carbon Sequestration

Carbon Measurements:

To evaluate C sequestration by soils and forest vegetation, sampling and analytical methods must be employed that provide reliable results. Sampling must be carried out by collecting soil samples by horizon, including, when possible, bulk densities and coarse fragments (> 2 mm) if the latter comprises a significant portion of the soil profile (Grossman et al. 2001). Topsoils (generally the upper 6-12 inches), and subsoils (horizons 30 to 60 inches in depth) are often considered for soil C measurements (Kimble et al. 2001). There are several methods used to measure soil C, but general measurements must include the evaluation of total carbon, organic carbon and inorganic C (e.g., carbonates CO_3^{2-}) (Soil Survey Laboratory Staff 1996). Plant C, however, is determined as the total carbon present in oven-dried materials. For both soils and woody vegetation, bulk density or wood density are required in order to convert carbon contents (e.g., weights or percentages) into mass-based measurements (pounds per acre).

Wyoming Soil Carbon Database:

Current soil's information available for Wyoming is obtainable through the Wyoming Geographic Information System's Center (WyGISC) at the University of Wyoming (Munn and Arneson 1998). Use of WyGISC soil's information along with NRCS's soil characteristics database (National Soil Survey Center - Soil Survey Laboratory 2001) allows us to produce a generalized map of soil carbon contents for individual counties as well as the state. Appendix D contains an example map of Campbell County. These maps can provide a baseline examination of estimated soil carbon and can be used in conjunction with data for climate, vegetation, land use, and alternative management practices to estimate potential storage capacity. While the information provided by the WyGISC soil's map is a generalized description of the soils within the

state of Wyoming, because our soils are highly variable due to climate, vegetation, geography and geology differences, maps and information produced using this approach should be considered for broad-scale planning and general assessment, and not for site-specific interpretations.

Verification Through Sampling:

If a carbon sequestration program is implemented in Wyoming, land use, management practices, climatic variations and other factors influencing soil carbon storage should be considered. One approach would be to establish reference sites in various agricultural ecosystems to demonstrate changes in soil carbon over time due to management or land use changes. This approach is currently being used by Canada where they established reference sites in cropland, grazing lands, and forest ecosystems several years ago. Nebraska is also in the process of establishing a soil reference sampling site network. This may be the most direct measure of carbon sequestration, but it also is very time consuming and costly. Selecting sites that represent more than just the specific site being sampled will be very complex and difficult. Any measurable changes in soil carbon will be very slow and likely require many years to exhibit significant change.

Century Model:

In 1997, the Natural Resources Ecology Laboratory (NREL) at Colorado State University carried out an assessment of how management decisions involving cropping and tillage systems might affect soil organic matter levels in Iowa (Brenner et al. 2001). The assessment utilized resource data on climate, soils, land use and management, long-term field experimental results, and the Century Ecosystem Soil Organic Matter Computer Model (Parton, et al. 1987, 1994; Mehterall et al. 1993). Phase I of the assessment was limited to croplands of Iowa utilizing

existing information on climate, soils, and management factors to estimate current rates of C sequestration in Iowa. This assessment resulted in an estimate of 2.5 million tons of C/yr. Phase II of the study was initiated in 1998 and involved all 99 counties. Local data was obtained from each county through a survey instrument. This provided data for model simulations that were not available in other databases. The Century Model estimated C changes for 203,000 different scenarios. This phase II assessment suggested that agricultural soils in Iowa were currently (1998 data) sequestering 3.4 million tons of C/yr (equivalent to 12 million tons of CO₂ per year). This is equivalent to an offset of 16.7% of Iowa's fossil fuel carbon emissions, based on 1997 emission estimates of 20.4 million tons of C/year (EPA 2001).

Conservation Approach:

An approach that may be more desirable and adequate to meet the needs of a soil carbon sequestration and marketing program is to use local and regional data representing the various management practices common to the area. These C sequestration estimates (see examples in Appendix B) could be credited to a producer if they were using that particular conservation practice, for example employing no-till cropping or Conservation Reserve Practices. Such a program could easily be adapted to USDA conservation programs that already exist and would likely have the accuracy that is needed and would be realistic for such a program (soil variability is extremely high and modeling or direct sampling and analysis would probably not provide greater accuracy).

Carbon Sequestration and Conservation Trading and Management

Carbon sequestration and carbon conservation each have a potential value in carbon credit markets in Wyoming. Both activities reduce and help prevent reintroduction of carbon into the atmosphere. A carbon credit is 1 metric ton (2,205 pounds) of pure carbon or its equivalent 3.66 metric tons of CO₂. Sequestration practices would include but not be limited to managed grazing, range enhancement, native tree reforestation, hybrid poplar plantings, urban tree establishment programs, conservation tillage/low till practices, soil salinity abatement practices, CRP, and other vegetation enhancement practices.

Carbon conservation is the action of minimizing oxidation of carbon from stored forms back into the atmosphere. Conservation practice examples would include erosion control, recycled wood products, grass/straw conversion to strawboard, industrial/commercial/residential energy efficiency programs, and biomass fuel utilization practices. Some practices such as conservation tillage/low till practices both sequester and conserve carbon. A ranch, farm, urban area, or industry involved in a carbon credit program would usually be both sequestering and conserving carbon in an integrated approach.

It is essential to understand that sequestered carbon that is sold or traded is considered both a commodity and a security. It is a commodity by virtue of being a tangible and physical substance, which can be measured, stored in a carbon sink such as soil, vegetation, and organic matter, and as a physical substance is not exchanged. It is a security due to the fact that the credit or value of the carbon sequestered or conserved is exchanged and has ownership subject to transfer by assignment. Carbon credits as securities may derive from contracts (easements), claims for money, and debts and rights against property. A carbon credit, in a security form, may

then be exchanged by second, third, or additional parties under varying agreements and types of compensation.

Trading and management typically involves both private sector and public government organizations in establishing and implementing a carbon trading/marketing program. Since our atmosphere and its carbon component is global in nature, carbon may be exchanged as credits with value on an international basis (i.e., industrial carbon dioxide emissions in Germany may be mitigated with carbon sequestered in Wyoming). This necessitates the need for standard units of measure such as the metric ton and scientifically defensible or agreed upon methods of measurement.

There is also a need for acceptable certification, authentication, registration, and verification of the carbon credit in conjunction with legal contracts and recorded property easements. Attestation of a particular carbon credit program from a quality control or auditing perspective usually involves a neutral third party. Insurance for the maintenance of carbon credits against natural events such as fires, floods or of man caused events such as termination of a contracted carbon sequestering best management practice is another necessary element. Insurance may be developed by simply retaining 20% or other appropriate amount of the carbon credits from each contract in a reserve account. A statewide pool of such contract reserves should then be sufficient to insure individual credit losses due to natural or man caused events.

Please note the Example Carbon Sequestration & Conservation Program Organizational Flowchart (Appendix E) for a perspective of a potential administrative and operational program for Wyoming. The organizations and agencies are not an all inclusive list and the format is portrayed to assist perspective of the needed types of entities and roles normally involved in a carbon sequestration and conservation program.

Sequestration and conservation activities are by economic and logistical necessity integrated in most carbon programs. An example would be the carbon sequestration improved by a no- or reduced till cropping program and the conservation of carbon due to the farmer decreasing the machine time per acre of ground and using bio-fuel diesel or ethanol in the tractor. A pasture or range application would be use of legume interseeding to enhance forage production thus increasing carbon sequestration and the decreased need for commercial nitrogen fertilizer application thereby conserving carbon.

The structure of carbon credit payments, governmental and industry partnering programs that provide technical and cost share assistance, and environmental value enhancements are all needed to realistically make a carbon project work for an individual and/or group of landowners.

The USDA programs such as the Wildlife Habitat Incentives Program (WHIP), Environmental Quality Incentives Program (EQIP), Wetland Reserve Program (WRP), Conservation Reserve Program (CRP) and similar programs would be a valuable component to many landowner implemented carbon programs. Likewise Wyoming Department of Agriculture, Wyoming State Forestry Division, and other natural resource agencies could provide technical assistance. Economically each program of service to a landowner needs to be in a matching form to maximize funding incentive and minimize cost for implementation. The Water Management and Conservation Assistance Programs Directory developed by the Wyoming State Engineer's Office is an extensive reference for local, state, regional, and national assistance programs that may be helpful to various landowner needs in carbon projects.

The value of a carbon credit is based upon national and international markets and has exhibited a steady increase in recent years. The supply is not anticipated to reach the demand for a number of years to come. Carbon emissions are currently substantially in exceedance of

sequestration and conservation balances. In part, this is due to the inconsistency of third world governments and their subsequent long-term ability to maintain carbon sequestration and conservation programs. This variable then places a higher premium on those regions where stability, infrastructure, technology, and public/private partnership support has a firm foundation.

Carbon credit contracts are normally for extended lengths of time with the entire payment for the duration of the contract in one lump sum at inception. In the case of unstable situations such as that might be found in a third world country, payments might be inclined to be on an annual basis.

An example of a contract in the United States for reforestation is the payment to landowners in northeast Washington for an 80 year growing cycle to plant fir trees, with prime growing sites receiving in excess of \$400/acre for carbon credits achieved during that period of time. Another example would be the establishment of a hybrid poplar plantation for municipal wastewater treatment that matures in 12-15 years for a carbon credit payment contract cycle of 12-15 years. In both of these cases, commercial thinning and eventual harvest is built into the management plan due to the fact that upon reaching maturity, the amount of carbon sequestered by the trees begins to decrease thereby meriting harvest and replacement plantings.

Implementation of a no- or reduced till cropping or a grazing management program to sequester carbon would probably require a minimum of 10 years and could extend to 15–20 years or longer in contract form. To implement such management practices on an operational basis and to achieve net carbon improvements on the landscape would require such periods of time. Wyoming has an abundance of grazing lands, which with proper management could enhance carbon sequestration and conservation. The carbon anticipated to be stored in grazing land soils through good management is significantly less than growing trees on prime sites, however.

Grazing land carbon contracts would then need the partnering program funding, technical assistance, and other incentives to make it viable for the average rancher. In addition to direct carbon credit payments there may need to be financial incentives in the form of tax credits, low and/or no interest loan programs for capital improvement needs, and grant cost share from a host of partners such as federal, state, or local organizations.

Potential Greenhouse Emissions Regulations

A voluntary carbon offset program in Wyoming could serve as a framework for cataloguing efforts to sequester carbon and reduce greenhouse gases (GHGs). This registry of GHG benefits may serve to help project proponents learn lessons from one another, lead to improved projects over time, as well as provide a compilation of total GHG benefits achieved in the state.

Presently, there is limited interest in investing in carbon benefits for several reasons. First, there continues to be ongoing scientific uncertainty both regarding the timing and magnitude of climate impacts and regarding the science of offsetting emissions. Before offset benefits will become counted as a tradable commodity, it must be understood which offset techniques successfully offset emissions and how these benefits should be counted. Second, there is substantial regulatory uncertainty as to which offset techniques might be allowed under any possible future requirements. It is not clear that there will be any near-term requirements to reduce GHGs and, in fact, the state of Wyoming has passed a law to prevent implementation of the Kyoto Protocol within the state. The rules of the game for counting offsets will have a significant impact on future investment decisions, so future carbon investors are not likely to invest until possible future rules have been set.

A Wyoming effort of voluntary “rules of the game” for offsetting GHGs could be useful in showing the importance of agricultural and range land options that identify GHG benefits. These types of projects have been slower to develop than forestry sequestration project and energy projects. This voluntary registry is not likely to motivate near term, substantial investment in offsets because the program will not alter the fact that there is tremendous uncertainty around any current investment in GHG offsets.

Voluntary Sequestration

The development of a market for carbon offsets is likely to go through a series of developmental stages. The first stage occurs when those prepared to experiment with offsets seek out suitable GHG offset projects. The second stage occurs when parties negotiate legally binding “bilateral agreements” where the entity in need of the carbon offset agrees to fund the project or otherwise compensate the supplier for undertaking the project that gives rise to the offset. The third and final stage is the actual exchange of registered notes or certificates representing a measured amount of carbon dioxide removed from the atmosphere and stored for a long period. This final stage is similar to the market for sulfur dioxide (SO₂), where “allowances” or “credits” are traded as a commodity among market participants.

There has been some limited experimentation with carbon offset techniques and some even more limited bilateral agreements. Because of uncertainties around the GHG offset commodity there is virtually no market trading in GHG benefits.

Projects in the agricultural (rangeland, forestland, cropland and agroforestry) sector, which are likely to be common in Wyoming, have to be further developed from both a scientific and regulatory perspective. Project examples that may have GHG benefits include:

- Cropland Retirement
- Buffer strip development
- Afforestation/Reforestation
- No-till farming practices
- Reduced tillage farming practices
- Reduced equipment energy use
- Fertilization with livestock manure
- Forest management

- On farm power generation from biomass
- Methane abatement from livestock waste
- Grazing management
- Implementation of agroforestry practices

Federal Registry of Offset Benefits

Under the Energy Policy Act (EPACT) of 1992, the federal government created a voluntary registry for offset projects. The program, called “section 1605(b) reporting”, allows both the reporting of annual emissions of GHGs and also to record specific reduction and sequestration projects.

The goals of the program, as outlined by DOE, are:

- To record emissions and achievements
- To inform the public debate; and
- To participate in educational exchanges.

Many large emitters of GHGs currently file annual 1605 reports to account for their direct GHG emissions reductions and offset projects. As part of this program, the Department of Energy (DOE) has developed detailed reporting guidelines to assist reporters in filing reports. These guidelines deal on a project specific basis to help reporters produce accurate reports in the areas of energy use, methane capture, and transportation.

Project reporters in Wyoming have the benefit of the 1605 registry. If Wyoming moves forward with a state-specific registry, the state should build on the federal 1605 program that is already in place.

Challenges Faced by a Voluntary Wyoming Program

In order for carbon sequestration or carbon credits to become a viable commodity there are a variety of hurdles that must be overcome. Carbon sequestration benefits need to be clearly understood, solidly defined and measurable. In order for any carbon investor to be enticed to invest in a GHG projects, the project must:

a) Provide real CO₂ reductions: The science behind agricultural and range land offsets is not yet well understood. Without a clear understanding of these benefits it is highly unlikely that any future regulatory rules will allow these type of offsets to be counted.

b) Benefits must be measurable: Once it is determined that these offsets provide real benefit, the program must determine how to handle issues such as the timing of benefits and the fact that sequestration benefits are not “permanent”.

c) Provide monitoring and verification (M&V): Clear and measurable benefits must be monitored and verified over a set period of time. Sophisticated M&V protocols are likely to be required especially in the area of sequestration—because of policy makers concerns that these benefits are difficult to measure and may disappear over time.

d) Show ancillary benefits: Because carbon is not currently regulated, it is important to investors that offset projects have other environmental and economic benefits as well. These should be defined and measured.

Example State Activities

There are a variety of state programs in place that may be useful to review as Wyoming considers whether or not to move forward with a voluntary sequestration program.

Oregon Forest Resource Trust

The Forest Resource Trust was established in 1993 by the Oregon Legislature to invest in under-producing forests. The original effort included state funding to move the effort forward. State funding has been limited, but it has received limited interest from carbon investors.

The Forest Resource Trust is an effort to provide funding to private non-industrial landowners to plant trees on lands that are currently understocked. In exchange for direct payment from the state for standard preparation and establishment, landowners enter into contracts with the state under which they agree to share a fixed percentage of the net timber harvest revenues from forests created by the Trust. The program, therefore, creates a revolving fund that will provide continuing funds for reforestation. Under the program, landowners choose when and if to harvest and there is no requirement to harvest at all. The revenue sharing component of the Trust provides incentive for landowners to grow and manage healthy, vibrant forests.

Greenhouse Emissions Management Consortium (GEMCo)

Carbon sequestration efforts between the Greenhouse Emissions Management Consortium (GEMCo – a consortium of Canadian industries) and the IGF Insurance Company in Iowa provide an example of exploring carbon offsets accrued from modified farming practices that increase the carbon stored in Iowa's rich soils. The project did not involve state participation but instead grew out of private market participants anticipating a potential market in the future.

The agreement was the first of its kind in that it applies to a broad spectrum of agricultural sources for GHG reductions. In this project, IGF solicited benefits from eligible farmers/landowners through its network of crop insurance agents. IGF is working with Cquest Lt., a network of service providers that define, measure, verify, audit, transfer, deposit, register, and assure the creation and transfer of GHG benefits.

In addition to the potential monetary benefit carbon credits can be for farmers, there is also agronomic and environmental benefits to increased soil organic material.

Carbon Sequestration Volunteer Programs

There are currently 25 states that are working on, or have completed, action plans that identify cost-effective options for reducing GHG emissions or enhancing GHG sequestration. These plans are not incentive programs, but instead laundry lists of potential projects in the state that, if implemented, will have GHG benefits.

In Illinois, afforestation is presented as a low-cost, “no regrets” option that provides benefits beyond emissions reductions. The State is moving forward to provide tree seedlings from the state’s nurseries which are then planted by landowners on marginal land.

Iowa completed a greenhouse gas study in June of 2001. To increase carbon sequestration in Iowa, the study recommended a conversion of an additional one million acres of marginal land into native forests through policy inducements, such as the 2002 Farm Bill, which is anticipated to reward agricultural practices that produce water quality and environmental benefits. Also included were recommendations for increasing on-farm efficiencies such as capturing methane gas at large hog lots, to use for heating farm buildings, drying corn, or producing hot water. At smaller operations, manure could be incorporated into the soil, where it is aerobically oxidized by microbes.

Education and Outreach

The goal of the committee is to provide outreach and education to those producers and landowners who might reap the many benefits of carbon sequestration, while also informing the general public. Committee members are considering hosting a state-wide forum devoted to carbon sequestration. This will provide the opportunity for legislators and the public to attend and hear the benefits of carbon sequestration both from a climatic standpoint and improvement of our natural resources.

One important step in the beginning of this process, is to gain support from the statewide agricultural organizations. This will be accomplished by passing resolutions of support for the program and encouraging each organization to form carbon sequestration sub-committees. To help accomplish this, committee members will give presentations at the annual meetings and conferences.

General written information will be distributed to the agriculture sector and the general public through a brochure on the subject, press releases, and articles in regional agriculture publications and local media. This information will also be available for local governments and legislators. A webpage has already been launched and will be updated regularly with new information. The website can be found under the Wyoming Department of Agriculture's site at <http://wyagric.state.wy.us/natres/carbon/index.htm>.

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Appendix A - Glossary

Aggregator- An organization who gathers and organizes project managers by carbon credit types in multiples that create quantities of carbon offsets that are more manageable and marketable through economy of scale to provide the assurances needed in a cost effective manner. An aggregator must ascertain (assure) the registration of the project proposed to sequester carbon.

Attestation- A process whereby a third party (internationally recognized for excellence) reviews the entire process and provides assurance (CERC Quality) that the CERC is a fully marketable B2B commodity.

Authentication- A process whereby a third party (State level organization or team) reviews the carbon baseline measurements and calculations for accuracy.

Carbon Baseline— Actual measurement of total current site carbon. All above and below ground vegetation, all soils carbon, mineralized and organic matter and soil organisms.

CERC™— Carbon Emissions Reduction Credit (Registered trademark of CQuest, Ltd.) Several types of CERC's can be created as follows: Bio-energy, Bio-fuel, Bio-product, Bio-Nutrient, Crop Land, Forest Land, Range Land, Urban Green Space, and Wet Land. Because CERC's are created by many various activities, managements, and methods, every CERC type has a particular set of procedures that must be followed and measurements that must be taken in order to accurately address the issue of carbon sequestered. The procedures must be standard so that they can be registered, authenticated, and verified.

CERC Creator— A third party actuary who is able to determine the risk factor associated with a particular management practice to create a CERC and provide insurance for any loss of carbon.

Easement- This is a form of "insurance" that covers credit loss whereby the value of the land may be encumbered to pay for the loss of credits in the event of a landowners direct and deliberate adverse action. The easement simply serves as a performance bond in fulfilling the long-term contractual agreement.

Insurance- Based upon risk of loss of carbon due to natural causes to cover potential loss of carbon reduction emission credit (CERC™).

Management Plan- A deliberate plan designed to improve true "sustainable" healthy production and storage of increased sequestered carbon. This plan must have a method by which measurements can be physically taken in order to determine a baseline and calculate the difference if the plan is followed assuring that both the plan and practice are valid.

Natural Causes- That which was not caused by man but by an unforeseen act of God.

Project Manager- One who formulates management plans that leads to the creation of carbon credits. Project managers must establish the carbon baseline and estimate future carbon condition based upon a management plan as it is applied. The Project manager must work with the landowner to coordinate the implementation of that management plan, furnishing the Aggregator with calculations and easements as required by each carbon type within the project.

Registration- A process whereby a third party (Regional-National-International) who provides detailed accounting of credits to insure non-duplication or miss-representation.

Saleable Credit- "A Saleable Credit"... is Authenticated, Registered, Attested, and continually Verified.

Verification- A process whereby a third party (State Level Organization or team) who continues to review the carbon measurements for the life of the contract, identifying needs to insure the validity of the credit continues.

Appendix B

PRACTICES THAT RESULT IN A NET SEQUESTERING OF CARBON IN PLANTS AND SOILS	
CROPLAND PRACTICES	Carbon Accumulation Tons/acre/yr
Converting from conventional tillage to no tillage	0.09
Converting from conventional tillage to ridge tillage	0.05
Converting from conventional tillage to no tillage and planting a winter cover crop	0.09
Applying fertilizer according to a nutrient management plan that maximizes the effective use of commercial fertilizers and maximizes utilization of animal waste fertilizer	0.09- 0.22
Apply irrigation water according to a management plan that maximizes crop production and minimizes use of energy from fossil fuels	0.02
Planting highly eroding or low producing dry cropland to permanent vegetative cover	0.13
Maximize dryland crop production by using rotations resulting in the highest effective use of soil moisture	+
Controlling diseases and pests to reduce crop losses	+
Using strip cropping to minimize soil erosion	+
Planting grassed waterways and buffer strips to minimize soil erosion and trap sediment	0.13
Using contour tillage to minimize soil erosion	+
Eliminate the use of summer fallow in rotations	0.09
Planting irrigated fields to tree farms	3 times the cropland storage
Growing crops that produce high amounts of above-ground or below-ground material for onsite decomposition	+
Minimizing burning of crop residue	+
Conducting field soil quality assessments and follow-up with appropriate practices	+

Use crop rotations that result in healthy soils	+

Appendix B (cont.)

PRACTICES THAT RESULT IN A NET SEQUESTERING OF CARBON IN PLANTS AND SOILS	
GRAZING LAND PRACTICES	Accumulation Tons/acre/year
Controlling annual plants	+
Seeding areas of low vegetation density with perennial plants	+
Improving/maintaining range health to a high level by proper stocking rates	0.134
Improving/maintaining range health to a high level by prescribed grazing	>0.134
Rotation grazing	+
Facilitating grazing management by developing livestock water facilities and fencing	+
Interseeding with legumes	+
Reduce the amount of brush on bush-dominated areas, preferably by mechanical methods	+
Maintain healthy grazing lands by implementing practices suggested by results of periodic vegetation condition assessments	+
FOREST LAND PRACTICES	Carbon Accumulation Tons/acre/yr
Managing forest stand densities to maximize annual woody growth rates; i.e.	+

thinning, planting additional trees	
Replanting burned and logged areas where natural forestation does not occur	+
Control pests and disease	+
Implement measures to minimize the potential for catastrophic wildfires	+
Implement a comprehensive forest management plan	+
Planting new areas of trees	237 million tons in 20 years

Appendix B (Cont.)

Planting tree species that produce highest amounts of wood	+
Selecting sites for new plantings according to the highest potential for growth rates	+
PRACTICES FOR OTHER LAND USES	Carbon Accumulation
Establish forests in riparian areas	237 million tons in 20 years
Planting trees and shrubs in non-forest areas for such purposes as windbreaks, wildlife habitat, energy conservation, and beautification	237 million tons in 20 years
Create or enhance wetlands	+
Control weeds, disease, and pests in windbreaks and other non-forest wooded areas	+
Plant shrubs and trees when reclaiming disturbed areas, such as mines	+
+Carbon Storage is increased, but research is needed to determine values	

Examples of the Potential Benefits of Implementing BMPs to Sequester Carbon

A farmer decides to change from a conventional tillage system on non-irrigated wheat-fallow cropland to a BMP consisting of no tillage operations. This change would sequester approximately 0.09 tons of carbon per acre per year. Assuming the value of the sequestered carbon is \$4.50 per ton, this equates to a value of \$0.41 per acre per year. An increase in the amount of grain produced and a reduction in equipment and labor costs are additional economic returns that would be realized by changing to minimum tillage. Increases in costs for herbicides and to acquire different equipment reduce the value of these returns. The net value of implementing this BMP is approximately \$10 to \$20 per acre per year.

A rancher decides to implement a Prescribed Grazing BMP on an area of rangeland. Watering facilities are added to increase the amount of area available for grazing. Fences are installed to facilitate rotational grazing which will improve the health and density of vegetation suitable for grazing by livestock and big game. Within 10 years, the amount of carbon sequestered averages approximately 0.13 tons of carbon per acre per year. Assuming the value of the sequestered carbon is \$4.50 per ton, this equates to a value of \$0.58 per acre per year. The number of marketable animals produced and the weight of the animals sent to market increases. Increased costs are incurred to install fences and watering facilities and for the additional labor for rotational grazing. This rancher's beef production increased from 15 lbs/acre/yr to 25 lbs/per/acre/yr. The rancher realizes that this change in the operation of the ranch also has the potential to increase the value of the land and will also improve conditions for fish and wildlife habitat thus creating the potential for revenue from hunting or fishing.